AN INVESTIGATION OF ROTIFER ABUNDANCE IN THE SACRAMENTO RIVER FROM 1973 TO 1993

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TRENDS IN ROTIFER ABUNDANCE IN AND UPSTREAM FROM THE DELTA, 1973-1993

INTRODUCTION

Rotifers are small planktonic animals that are consumed by larval delta smelt and striped bass, as well as other fish species. Their abundance in the Sacramento-San Joaquin Estuary declined sharply in the late 1970's (CDFG 1987). Possible reasons for the decline are a decrease in the phytoplankton food supply of rotifers and increases in rice field herbicides entering the Sacramento River. This report investigates the decline by examining rotifer abundances in the Sacramento River at Hood upstream from the Delta and in the Sacramento River from Rio Vista to Collinsville for the period of record, 1973 to 1993. Cladoceran and copepod abundances are also examined to see if they experienced similar trends.

METHODS

Rotifers were sampled from bottom to surface with a 15 l/min capapcity pump in mid-channel of the Sacramento River at Hood (station C3) and from Collinsville to Rio Vista (stations 60 to 68) monthly in March and November and twice monthly from April to October, 1973 to 1993. Ten-minute bottom to surface tows with a Clarke-Bumpus net were also made at the same stations and times to sample cladocerans and copepods. Abundance of zooplankton was calculated as numbers per cubic meter of water. Water samples were taken from 1 m below surface for chlorophyll *a* measurements.

RESULTS

Rotifer abundance showed long-term downtrends at both Hood and Sherman Island (stations 60-68) in spring, summer and fall (Fig. 1). Abundance was highest from 1973 to 1977 and was often higher at Hood than at Sherman Island. However, neither copepod nor cladoceran abundance declined at either location (Figs. 2 and 3). Plankton abundance is often an inverse function of river flow (Brook and Rzoska 1954, Talling and Rzoska 1967, Winner 1975). To determine how flow affected rotifers, rotifer abundance at Hood was plotted against Sacramento River flow at the I Street Bridge, Sacramento for springs of 1973-92 (Fig. 4). Abundance did not show any trend with flow although it tended to be somewhat lower at flows <25,000 cfs. Instead abundance was significantly correlated with chlorophyll *a* concentrations in all seasons at both Hood and Sherman Island (Figs. 5 and 6). The significance levels were higher at Hood.

Rotifers may be harmed by herbicides that drain out of Sacramento Valley rice fields into the Sacramento River. A variety of herbicides and pesticides have been applied to the fields but the one most heavily and consistently used has been molinate. Its application rates were relatively low from 1973 to 1977 and then increased steeply (Fig. 7). Molinate is more toxic to aquatic organisms when another herbicide, thiobencarb, is present (Cornacchia et al. 1984). Thiobencarb was first used in 1981. These herbicides are present in the Sacramento Rive for only a few days when the rice fields are drained in May or June (Cornacchia et al. 1984). An ANOVA was run for log rotifer abundance vs.log chlorophyll *a* and log molinate in May and June 1973-1992.. Results of t-tests for the significance of the regression lines of log rotifers vs. log molinate and log chlorophyll *a* at Hood showed that rotifer abundance was significantly related to both molinate and chlorophyll *a* (Table 1).

However, herbicide application figures are misleading because they do not reflect the amounts actually entering the river and since 1984 changes in rice field water management have been made to increase chemical degradation in the fields prior to releasing water to the river and thus reduce the potential toxic effects of these chemicals on aquatic life. As a result, the mass transport of molinate and thiobencarb at in the Sacramento River at Sacramento was low from 1987 to 1991 (Fig. 9) in spite of high application rates (Fig. 7). An ANOVA using log rotifer abundance and log chlorphyll *a* at Hood, and log pounds of molinate transported past Sacramento in May and June 1982 to 1991 (the years for which mass transport data was available) showed that chlorophyll *a* was significant but molinate was not (Table 2).

A further examination of the possible effects of herbicides was done by examining survey abundance of rotifers at both locations in 1977, when molinate application rates were low, no thiobencarb was applied, and river flow was low, and in 1984, also a low flow year, but with much higher molinate application rates plus thiobencarb application. Rotifer abundance peaked at Hood and Sherman Island in June 1977 but in June 1984 it declined slightly at Hood (Fig. 8). At Sherman Island in 1984 abundance declined gradually from March to August and then increased. No effects of herbicides could thus be detected.

DISCUSSION

Rotifers and phytoplankton at Hood most likely originate in reservoirs on the Sacramento River and its tributaries. Although rotifer generation times are on the order of a few days at summer temperatures they are probably moved downriver too fast to allow abundance to increase. In a 1963 study, phytoplankton increased slightly from Keswick Reservoir to the Delta and then showed a large spike in concentration at Isleton, ~20 km downstream from Hood where water velocity decreased (Greenberg 1965). Rotifers would not respond as quickly as phytoplankton to a change in water velocity and indeed usually showed similar abundance levels at Hood and in the Delta at Sherman Island. The concentrations of both rotifers and phytoplankton at Hood most likely reflects conditions in the reservoirs.

The ANOVA results for 1982-91 and the 1977 and 1984 abundance profiles indicate that herbicides did not have an observable effect on rotifer abundance. If rice field herbicides did cause the rotifer downtrend before 1984, the trend should have been reversed after water management practices reduced herbicide loading in the Sacramento River. Rotifers are less sensitive to some toxicants than cladocerans and copepods and may show "blooms" after pesticides reduce the copepods and cladocerans that compete with them for food or prey upon them (Lucassen and Leeuwangh 1994). The failure of the more sensitive copepods and cladocerans to decline at Hood (Figs. 2 and 3) makes it even more unlikely that toxics are a cause of the rotifer decline.

In addition to rice field herbicides significant quantities of the dormant spray pesticides (diazinon, methidathion, chlorpyrifos and malathion) are applied to orchards in the Central Valley during January and February (Kuivila and Foe 1995). These produce pulses of pesticides in the Sacramento River in February that are acutely toxic to a cladoceran, *Ceriodaphnia dubia.* But these pesticides are apparently washed out of the river by March, the beginning of our sampling period for rotifers, and hence have no relevance to this analysis.

The significant relationships between rotifer abundance and chlorophyll *a* at Hood may reflect cause and effect since rotifers are known to feed on phytoplankton and their reproductive rate has been shown to be positively correlated with phytoplankton abundance (Edmondson 1965). The long-term downtrend is, therefore, more likely to be a result of lower phytoplankton concentrations in the Sacramento River and ultimately in the reservoirs that supply water to the river than an effect of toxicants.

ACKNOWLEDGEMENTS

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LITERATURE CITED

Brook, A.J. and J. Rzoska. 1954. Influence of the Gebel Aulyia Dam on the development of Nile plankton. Journal of Animal Ecology 23(1):101-114.

California Department of Fish and Game. 1987. Long-term trends in zooplankton distribution and abundance in the Sacramento-San Joaquin Estuary. Exhibit 28, State Water Resources Control Board 1987 Water Qualtiy/Water Rights Proceeding on the San Francisco Bay/Sacramento-San Joaquin Delta, Sacramento, California..

Cornacchia, J. W., D.B. Cohen, G.W. Bowes, R.J. Schnagl, and B.L. Montoya. 1984. Rice herbicides: molinate and thiobencarb. California State Water Resources Control Board Toxic Substances Control Program, Special Projects Report No. 84-4sp, Sacramento, California.

Edmondson, W.T. 1965. Reproductive rate of planktonic rotifers as related to food and temperature in nature. Ecological Monographs 35:61-111.

Greenberg, A.E. 1964. Plankton of the Sacramento River. Ecology 45(1):40-49.

Kuivila, K. M. and C.G. Foe. 1995. Concentrations, transport and biological effects of dromant spray pesticides in the San Francisco estuary, California. Environmental Toxicology and Chemistry 14(7):1141-1150.

Lucassen, W.G.H. and P. Leeuwangh. 1994. Responses of Durban 4E insecticide in a pond experiment. Pages 517-533 in Aquatic mesocosm studies in ecological risk assessment. R.L. Graney, J.H. Kennedy, and J. H. Rodgers Jr., editors, CRC Press, Boca Raton, Florida.

Talling, J.F. and J. Rzoska. 1967. The development of plankton in relation to hydrological regime in the Blue Nile. Journal of Ecology 55:637-662.

Winner, J.M. 1975. Zooplankton. *In*: River Ecology. Studies in Ecology, editor, B.A. Whitton. University of California Press, Berkeley, California.

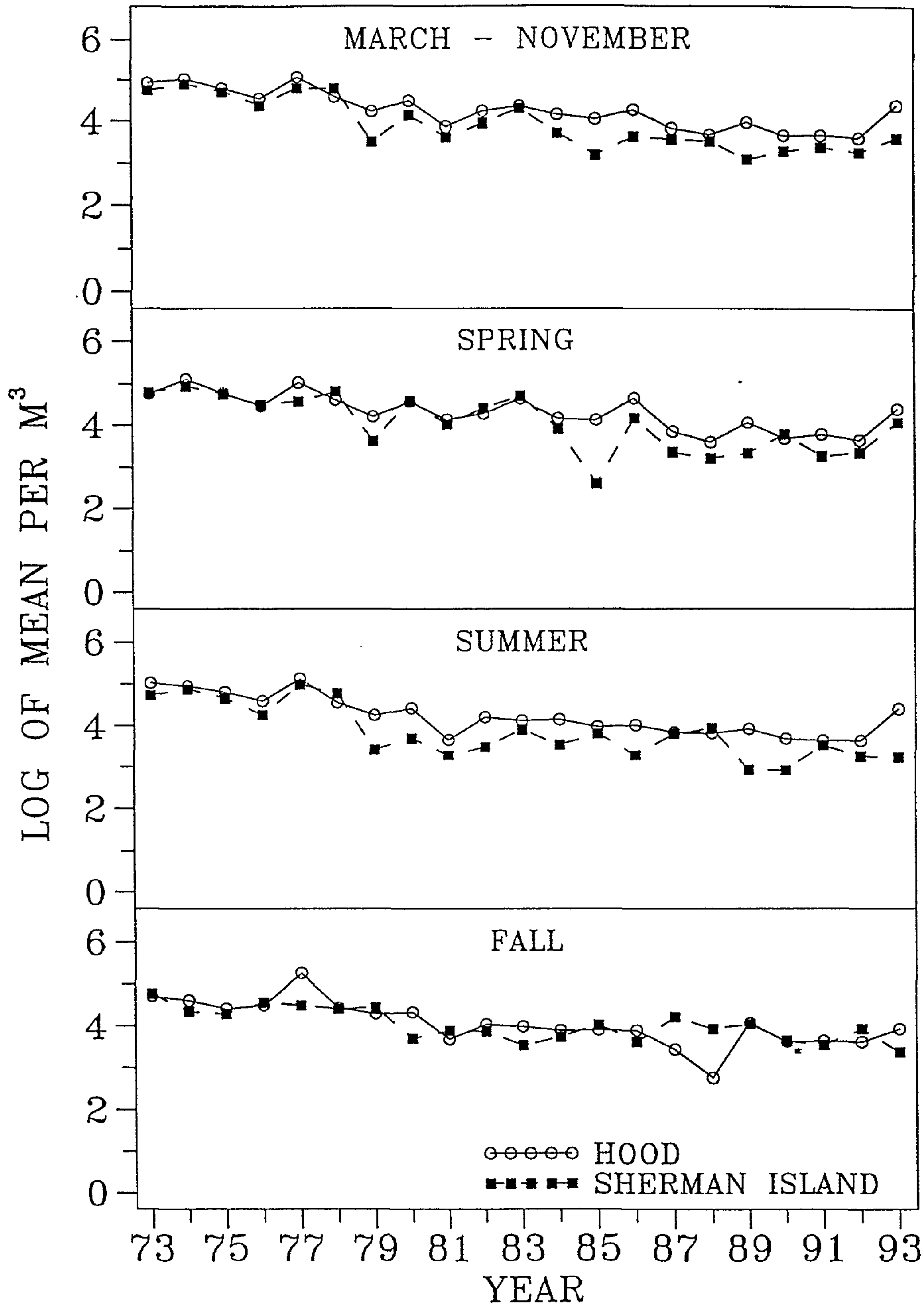

Fig 1. TOTAL ROTIFERS
IN THE SACRAMENTO RIVER
AT HOOD AND SHERMAN ISLAND

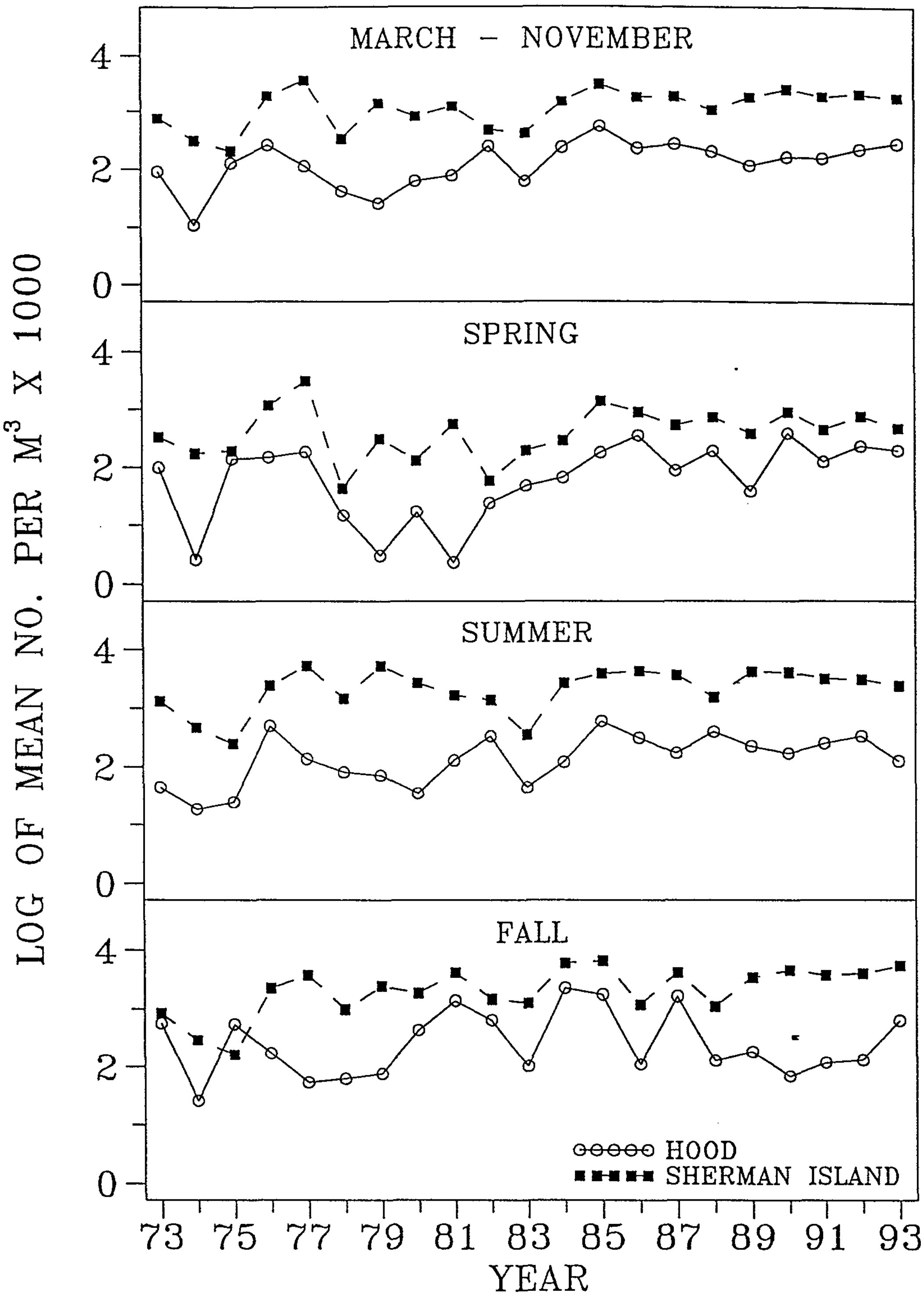

Fig. 2. LOG OF COPEPOD ABUNDANCE AT HOOD AND SHERMAN ISLAND 1973 - 1993

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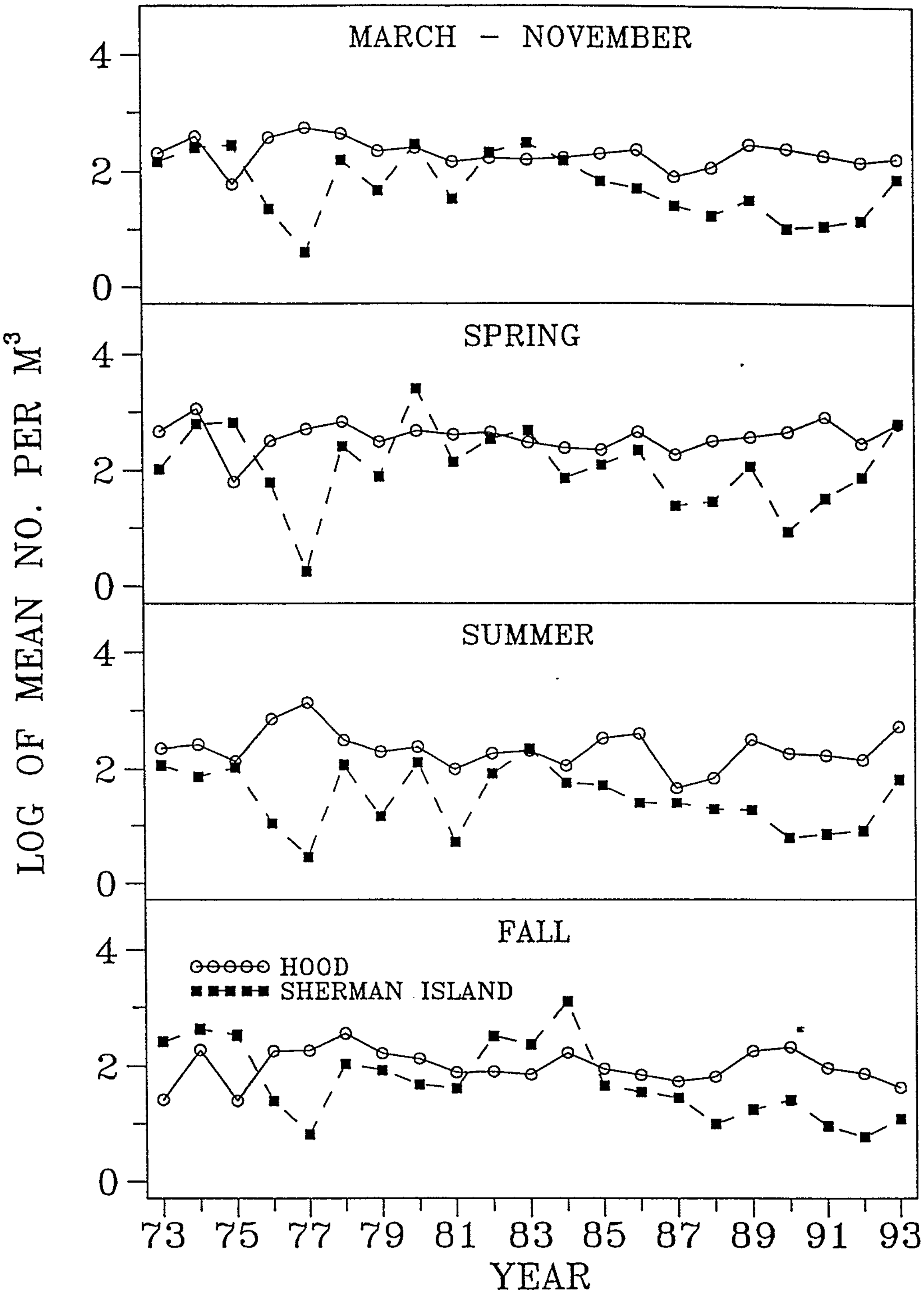

Fig. 3. LOG OF CLADOCERAN ABUNDANCE AT HOOD AND SHERMAN ISLAND 1973 – 1993

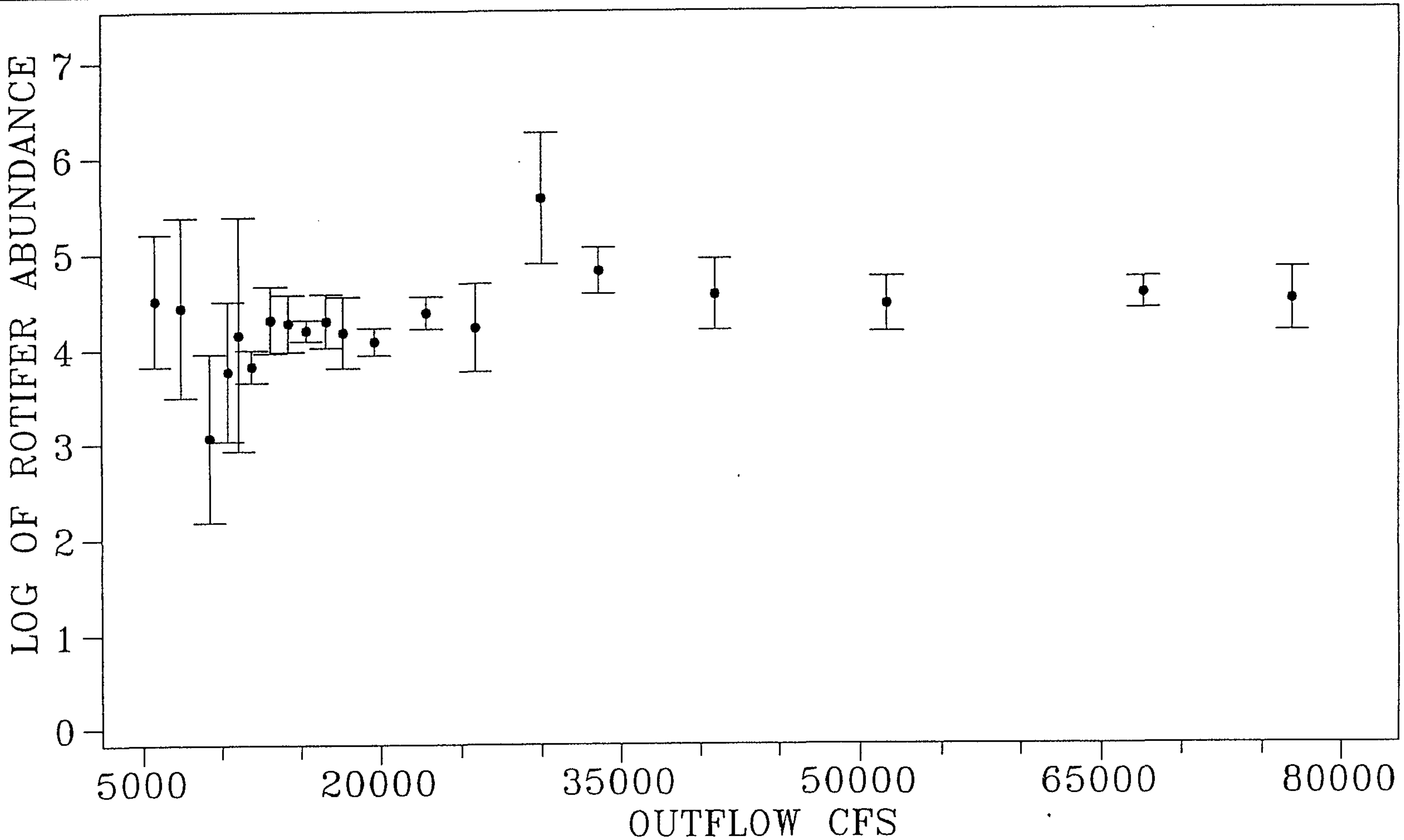

Fig. 4. ROTIFER ABUNDANCE BY FLOW CLASS AT HOOD, SPRING 1973 – 93, MEANS AND 95% CONFIDENCE INTERVALS

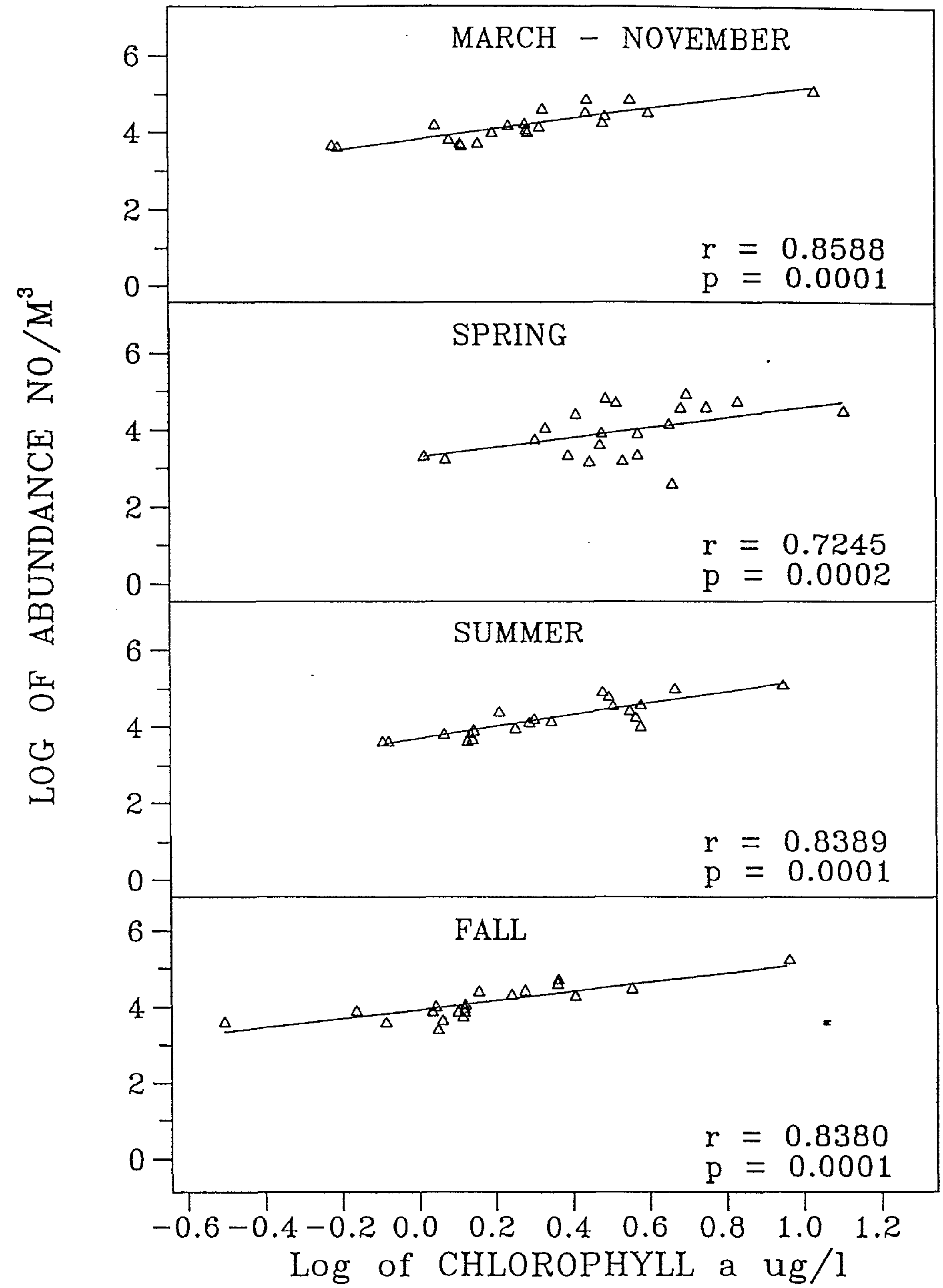

Fig. 5. LOG OF ROTIFER ABUNDANCE VS LOG OF CHL α SACRAMENTO RIVER AT HOOD

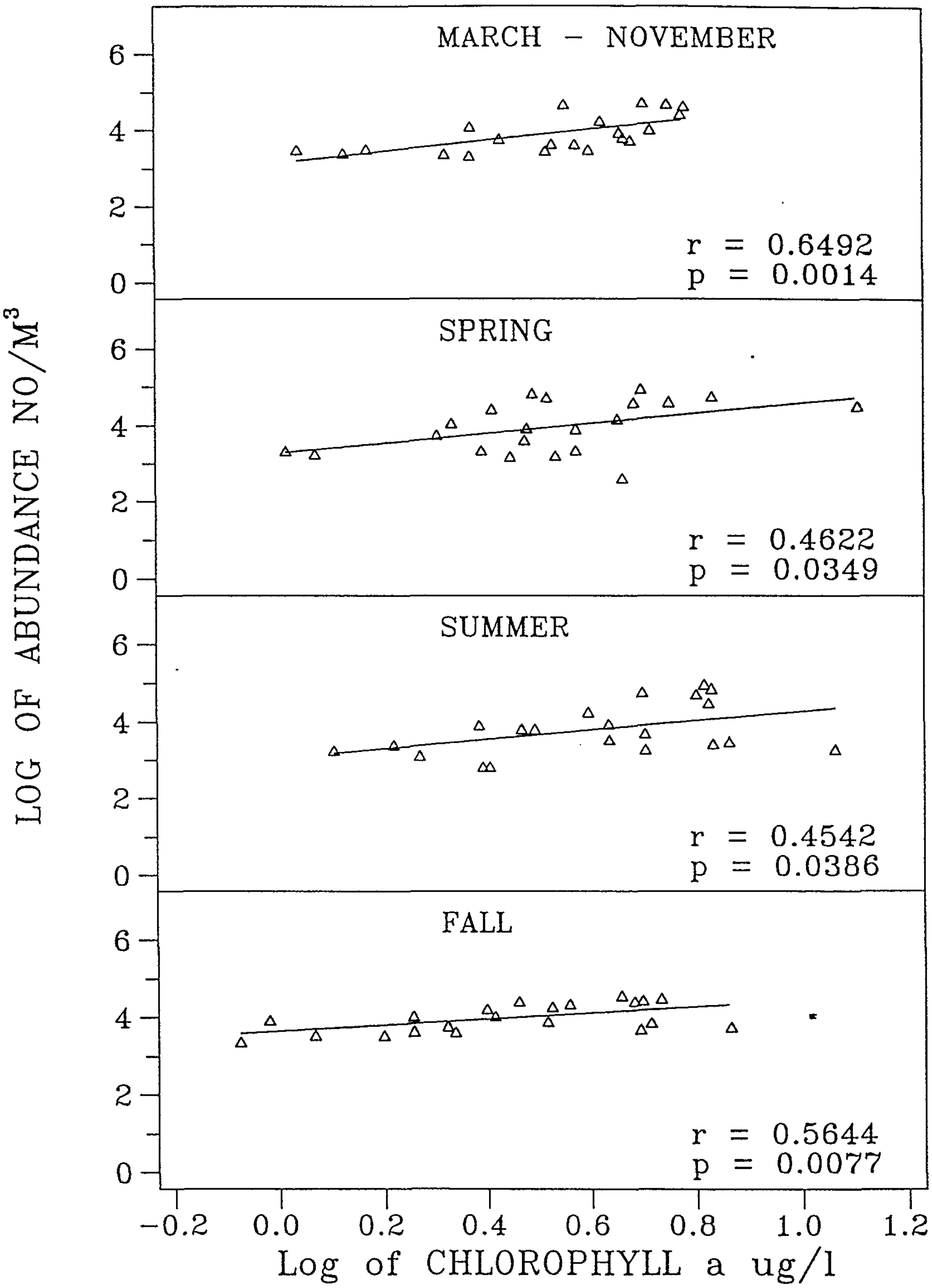

Fig. 6. LOG OF ROTIFER ABUNDANCE VS LOG OF CHL α
SACRAMENTO RIVER AT SHERMAN ISLAND

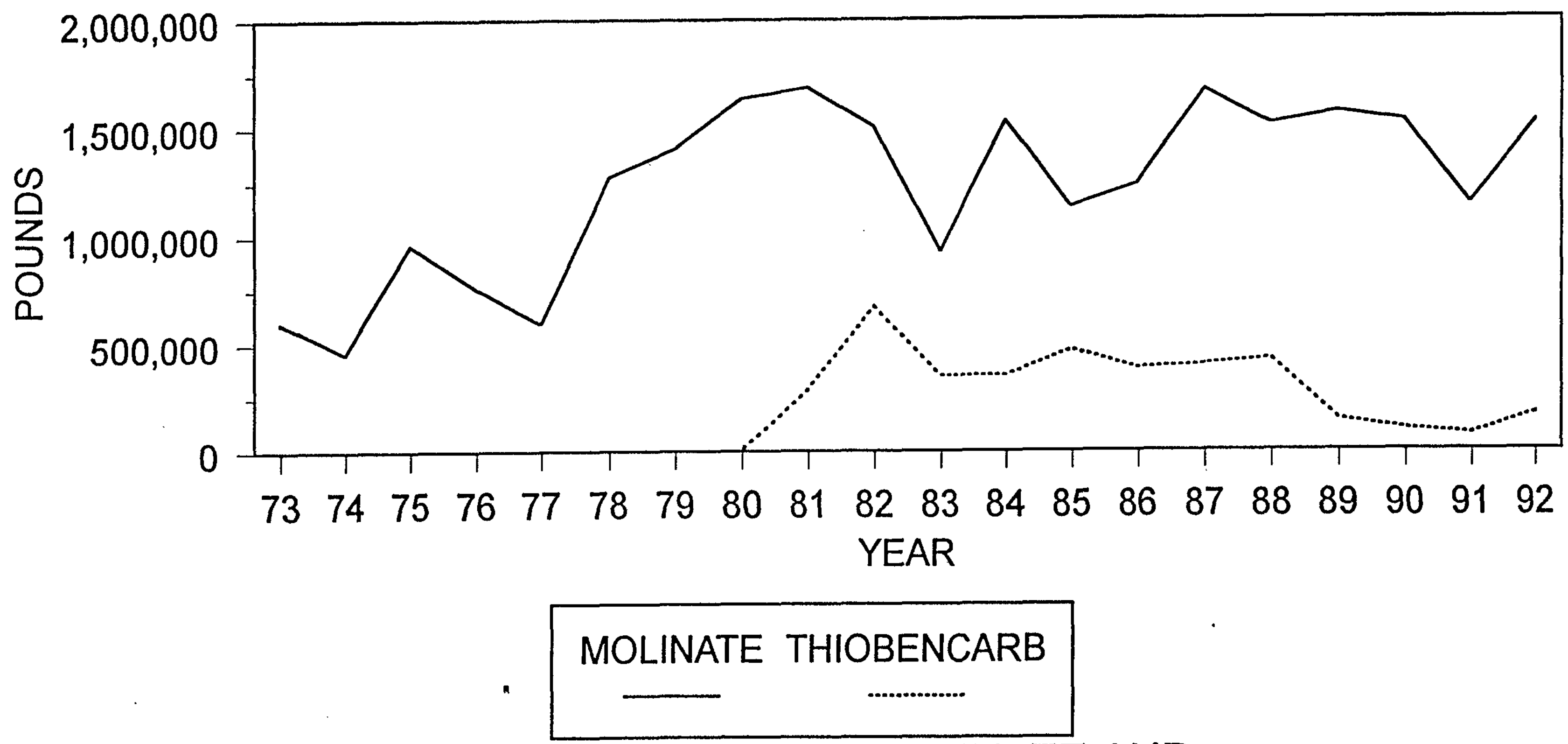

FIG. 7. POUNDS OF MOLINATE AND THIOBENCARB APPLIED ANNUALLY TO RICE FIELDS FROM 1973 TO 1992

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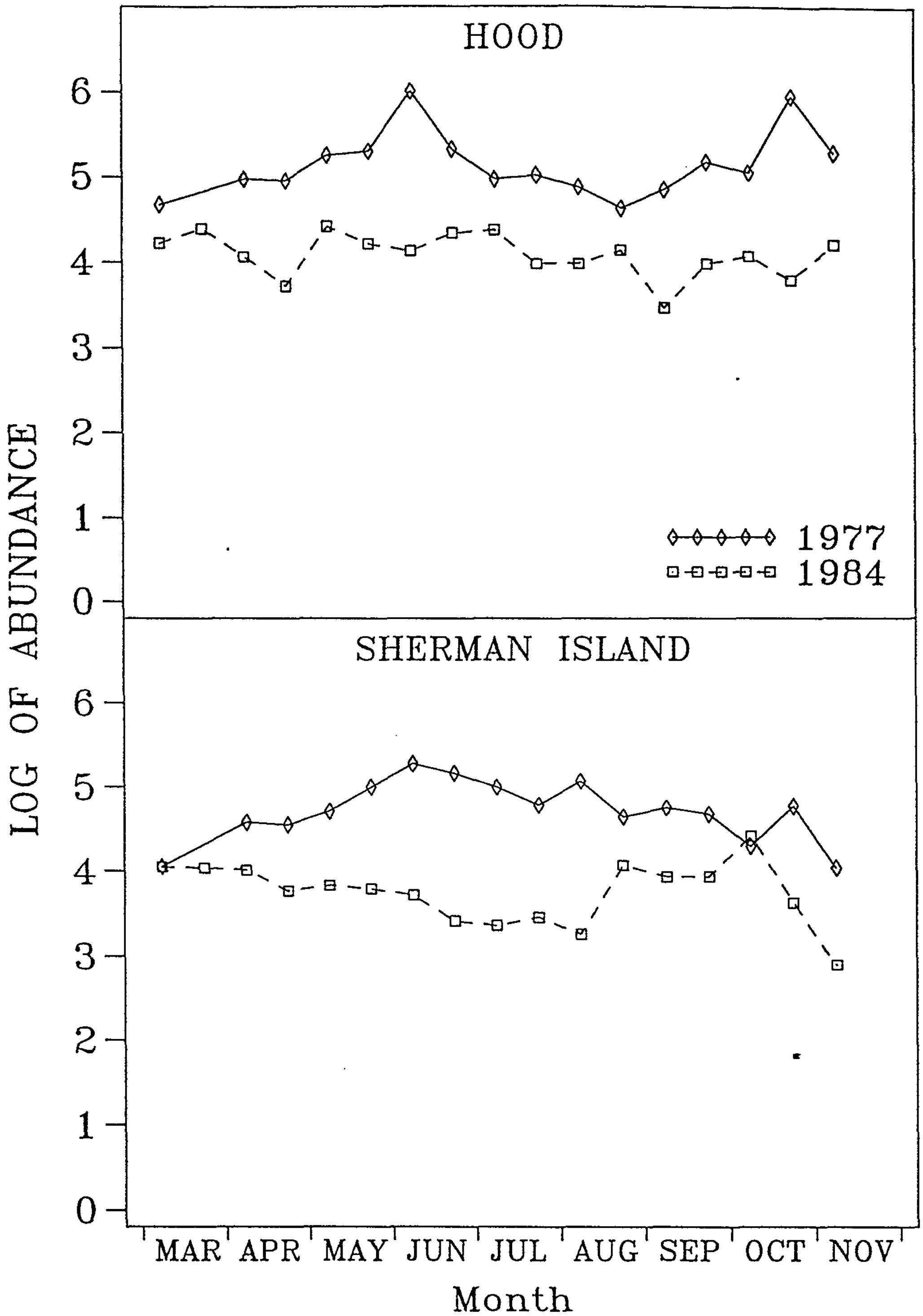

Fig. 8. ROTIFER ABUNDANCE BY MONTH AT HOOD AND SHERMAN ISLAND 1977 AND 1984

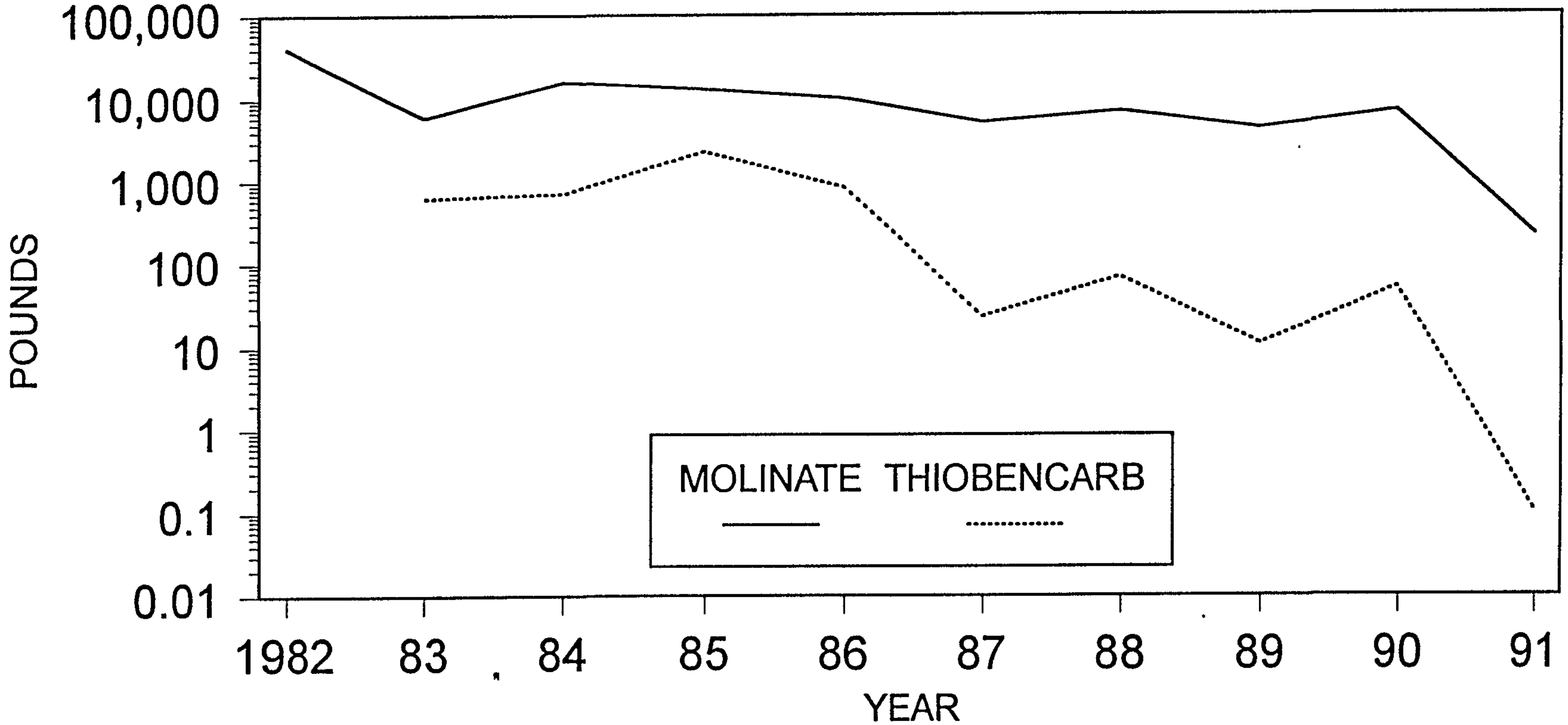

FIG. 9. ESTIMATED MASS TRANSPORT OF MOLINATE AND THIOBENCARB IN THE SACRAMENTO R. PAST SACRAMENTO, 1982-91

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Table 1. Results of t- tests for slopes of regression lines of log chlorophyll *a* and log molinate (pounds) vs. log of rotifer abundance at Hood in May and June 1973-92, n=17.

Variable	b
Molinate	-7.64×10^{-7}**
Chlorophyll *a*	0.915**

**Significant at 0.01

Table 2. Results of t-test for slopes of log chlorophyll *a* and log molinate (pounds) transported past Sacramento vs. log rotifers at Hood in May and June, 1982-1991, n=10.

Variable	b
Molinate	-0.021ns
Chlorophyll *a*	1.549 **

*Significant at 0.01

ns = not significant